

THE PREVENTION OF
DENTAL CARIES.

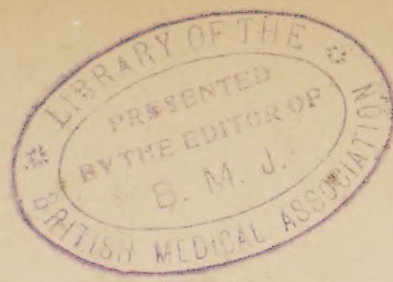
SIM WALLACE.

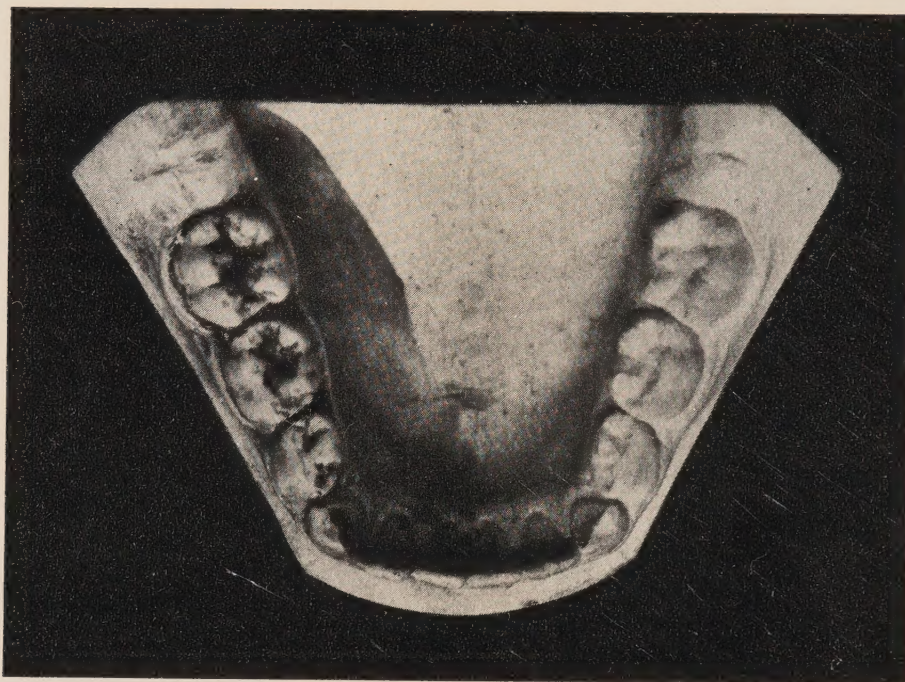
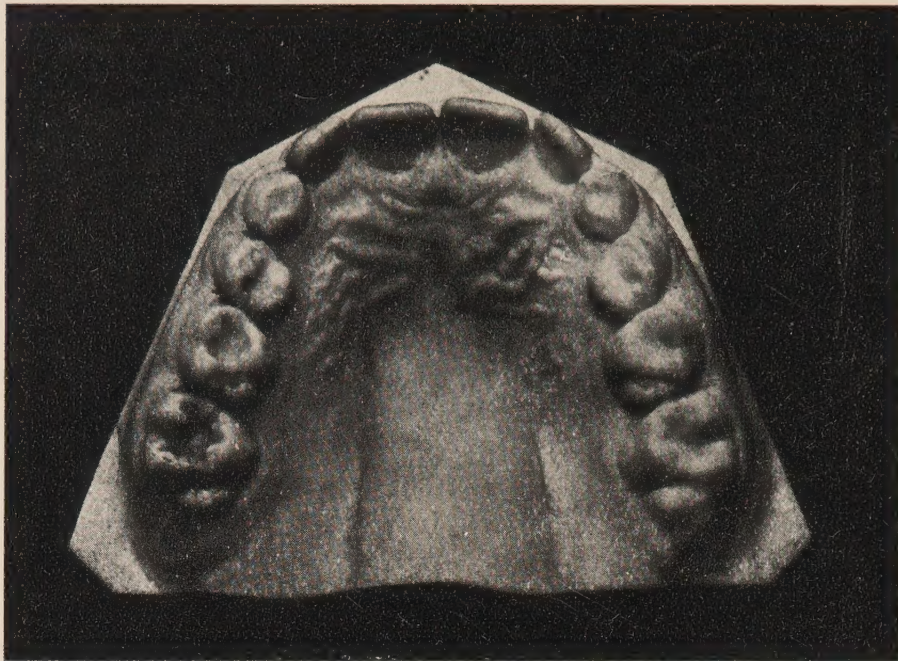
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Typical models of child's mouth, aged 10, brought up in accordance with the principles advocated, without resort to any artificial aids to keep the teeth and gums clean, healthy, and free from any trace of caries.

The right side (the left on this page) of each model was dipped into carmine, let dry, then brushed. This was repeated twice. The photographs indicate how imperfectly the crevices and interdental spaces of teeth are cleaned. Incidentally it may be noted that the models show a particularly perfect set of teeth without crowding, and consequently relatively easy to clean. The child, one of the 14 referred to page 33, having been brought up on food requiring mastication, has worn the cusps especially of the temporary teeth, so that the crevices are relatively easily brushed.

THE PREVENTION OF DENTAL CARIES.

CANCELLED

By

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DENTAL CARIES.

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Preface and Introduction.

Dental Caries is one of the most easily and certainly preventable of diseases, and there would seem now to be no valid excuse for the bringing up of children with decayed teeth, together with all the pathological results which they give rise to. Unfortunately, so far it is only those who have become interested in the subject, and who are themselves possessed of the required knowledge to come to correct conclusions on the subject, who know the simple secrets of prevention. That is to say, a goodly proportion of the dental profession and here and there a few medical men who have paid attention to the long and laborious investigations which have led to the solution of this important problem. It is with the idea of letting what is already known to a few become more widely known, among medical men more especially, that I venture to publish this pamphlet. Those who find the subject of interest or importance would do well to make their knowledge more secure, by acquainting themselves not only with the outlines of the means of preventing the disease as presented in these pages, but also with at least a general knowledge of the pathology and the etiology of the disease, because for some considerable time, incredulity, ignorance, prejudice, vested interests and the commercial spirit are likely to continue to make a stubborn resistance to the diffusion of the truth. It would be a great service to mankind if a goodly number of medical men would become thoroughly acquainted with the subject so as to rid the land of ideas which are now definitely known to be wrong, and indeed often actually markedly instrumental in causing the disease. Medical men should certainly make sure that it is not *their* precepts which are largely responsible for the widespread prevalence of the disease. Those who would like to supplement their knowledge may be recommended to consult the more recent standard text-books, *e.g.*, J. F. Colyer's "Dental Surgery and Pathology," or the larger "System of Dental Surgery" edited by Mr. Norman Bennett, about to be published by the Oxford Medical Press. Therein they will find the ground work of the subject sufficiently thoroughly treated to let them master all important points. The references at the end of this pamphlet will also help anyone with regard to any special point on which he may desire to have further information.

It would be difficult for me to speak too strongly on the great importance of the study of this subject at the present time; not only because dental caries is such a general, and in its ultimate results so frequently such a fearful scourge, but also because there

has been such an extraordinary change during the last few years in the conceptions of the dental profession with regard to the cause and the prevention of the disease. Formerly, the cause was vaguely supposed to be hereditary, constitutional, intangible and irremediable; now it is definitely known to be simple, definite, tangible and remediable. Correspondingly from the most doleful pessimism the profession has passed into a most optimistic attitude. Instead of listening to papers on "The Teeth as the Beginning of the End of the Civilized Race," we now hear of "the decimation of the ranks of the dentists which will follow when once the eyes of the public are opened to this scourge and its possibilities of prevention." And "that we look forward with every belief in the ultimate conquest of the disease. We see a future people free of it and marveling that those of to-day could have suffered so long and so patiently. We imagine them asking themselves what strange perversity could have filled the mind of people who were willing to spend thousands, nay millions, of pounds a year on the cure of a disease, upon discovering the cause of which they would not spend a penny. Can we wonder at them if they think thus? For everywhere we see signs of this dreadful malady; it ruins the beauty of many, it enfeebles those who would be otherwise healthy, it helps to fill the workhouses and poor infirmaries with preventible sickness, it is the direct and indirect cause of a waste of fabulous sums of money."

From multitudinous researches which seemed to bring us no nearer to the practical solution of the problem of dental caries, we have come to hear that caries is essentially a preventable disease. From a feeling of shame that the dental profession were unable to solve the problem of prevention it is now said that by having done so we have "ennobled the avocation of the dentist in the medical and scientific world." Instead of anticipating the continued increase of dental caries, we confidently anticipate its more or less complete extinction. And for those who dread their annual visit to the dentist we can give the most satisfactory assurance that this, though it may continue to be expedient, will be but rarely necessary. Moreover, we can say that we are on the eve of a more or less systematic crusade. A crusade no doubt initiated by us in establishing rational methods for the prevention of caries, but now about to be passed on to those whose position and authority fits them in some ways more satisfactorily for carrying home the truth to the mass of the population. Thus, Dr. James Wheatley (Medical Officer of Health for Shropshire) has set Medical Officers of Health an excellent example. After studying the subject for himself he brought it forcibly before the medical profession in his branch. He then lectured to the school teachers in his neighbourhood, and finally prepared leaflets for the instruction of the parents of the school children in his county. Like many others who have studied the subject, he came to appreciate its enormous importance not only from the point of view of the teeth, but also from the point of view of health in general. Thus, like others who have troubled to study the subject, he re-echoed the sentiments of those who feel that the principles of dietetics suggested by a study of the food in relation to

the teeth, will yet be found to give rise to the greatest triumph over disease that has as yet been recorded in the annals of disease. I have heard further, that other Medical Officers of Health are about to proceed in like manner. We cannot wonder at this ; in fact, we could only wonder if other Medical Officers of Health did not do so, because the principles are so well established and there is no other method known which would have any appreciable effect in preventing the disease. Moreover, the method costs nothing, and indeed, if a considerable tax were put on sugar a large amount of revenue would be derived, while a corresponding amount of good would follow.

It would seem from many considerations besides those to which attention is directed in the following pages, that the most important principle in dietetics will prove to be that which claims that the diets which are recommended should be such as will leave the different parts of the alimentary canal in a healthy or hygienic state. When once it is pointed out, this appears so obviously the first and most necessary consideration that it would seem incredible that it should continue to be overlooked in the future. The amount of nutrition, or the digestibility, or the absorbability, or the number of " calories " which may be derived from an article of diet, should always be preceded by the consideration whether it leaves the mouth and alimentary canal in a healthy or hygienic state. Yet it is obvious that in the past this consideration has been entirely overlooked ; and it would be difficult, if not impossible, to find a well-known writer on dietetics (except Dr. Harry Campbell) who has paid sufficient attention to the subject to be able to give any idea whether the articles of diet which he may be recommending are calculated to ruin the dental armamentarium or keep it in a hygienic state. Similarly the treatment of diseases resulting from the frightful state that the mouth and teeth get into as the result of unhygienic methods of feeding without knowing how to alter these unhygienic habits, is peculiarly unscientific and, instead of curing the trouble, has led in the past to an untold amount of chronic ill-health.

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The Prevention of Dental Caries.

Uncertainty may still exist with regard to the reasons why the teeth in certain mouths fall a prey to caries while in others they do not, but the pathology of the disease and the nature of the immediate or exciting cause is definitely and accurately known and fortunately beyond the limits of controversy. It is now universally admitted that dental caries results directly from the fermentation of carbohydrates in the crevices of, or between teeth, or more generally in such situations as carbohydrates are liable to lodge unduly and permit of fermentation. The facts upon which this generalization is based are of so great importance from the point of view of prevention that a few words on causation may at the outset be desirable. Various conditions, such as warmth, moisture and the presence of bacteria, do not require to be discussed at present. These conditions are so constant they hardly need be more than referred to. The variable condition or antecedent, which when present caries inevitably follows, and which when absent caries cannot take place, must be more fully noted. This antecedent or condition is the undue lodgment or stagnation of fermentable carbohydrates in more or less immediate contact with the teeth and undisturbed by the free access of saliva. This being so, what must be considered is how the undue lodgment of carbohydrates may be prevented. It is obvious that the teeth themselves may be of a shape such as will predispose to the lodgment of carbohydrates, or they may be so arranged as to predispose to the undue retention of viscous and fermentable food-stuffs, or their relation to surrounding parts (gums) may be such as to predispose to stagnation. In other words, the predisposing causes of caries are abnormal pits and crevices, irregularities of the teeth, recession of the gums and abnormal relations of the gums, more especially round the wisdom teeth. Practically all these predisposing causes may easily be prevented. All the predisposing causes have their importance and each will be considered separately.

THE PREVENTION OF DEVELOPMENTAL DEFECTS IN THE TEETH (HYPOPLASIA).

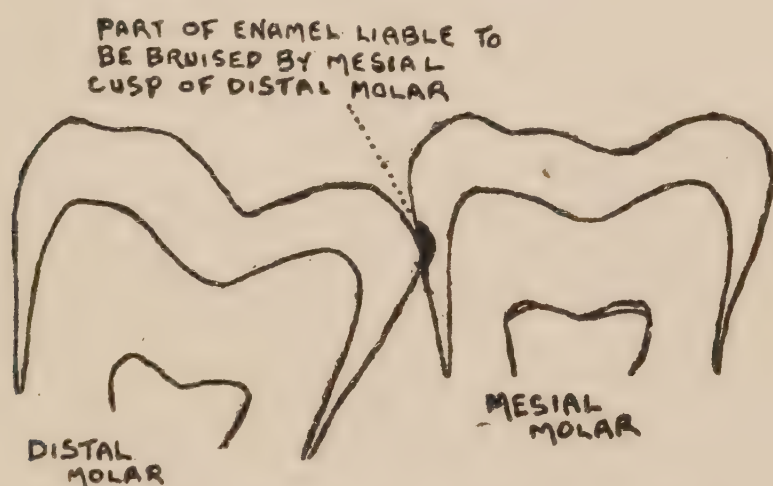
It is generally recognised that the pits and grooves (hypoplasia) which result from the defective formation of the enamel are caused by disease during its formation. Measles and scarlet fever are said

to be the diseases most commonly giving rise to such defects ; but other severe constitutional diseases may produce similar results. It is, of course, obvious that such diseases should, if possible, be prevented and the general hygienic precautions against them should be taken. In addition to what may be called the recognised methods of preventing such diseases it should be observed that a dirty mouth is always dangerous to the health of young children, and it is doubly objectionable should such infectious diseases also be contracted. It happens that at the age (1-3 years) when the teeth susceptible to hypoplasia are being formed, the food is most frequently presented to children in a soft or pappy form, which has little or no detergent effect on the teeth and, moreover, during these years the temporary teeth are seldom brushed sufficiently to keep them clean. It thus happens that these infectious diseases may be made more severe and prolonged or complicated by the insanitary state of the mouth and the consequent pollution of what food the child may take. As the fact of a child having measles or scarlet fever during the formation of the enamel (of the susceptible teeth) does not necessarily result in hypoplasia, it is possible that the keeping of the mouth clean may sometimes be sufficient to prevent hypoplasia should unfortunately the infectious disease take place at such time. It would indeed appear that the malnutrition—which may sometimes be prolonged and severe—resulting from an unhygienic state of the mouth and alimentary canal may in itself be the cause of many cases of hypoplasia ; for perhaps the most common reply to questions with regard to any particular child which shows hypoplasia in later life is that it was very delicate—possibly rachitic—and subject to severe indigestion during childhood. Defective development of the enamel has also been attributed to the bottle-feeding of infants. When this is not carefully carried out, especially with regard to sterilization of the milk, disease and malnutrition are likely to supervene, and it is further noteworthy to find that hypoplasia is more common among the children of the poor than of the well-to-do.³⁵ This may be presumed to indicate that the less hygienic the surroundings the more likely is the disease to occur. To sum up it may be said that in addition to ordinary hygienic precautions and breast-feeding, it seems probable that hypoplasia might largely be prevented by keeping the mouth clean. (The methods of doing this will be referred to subsequently).

THE PREVENTION OF THE IRREGULARITIES OF THE TEETH.

Abnormalities in the position of the teeth are much more important as predisposing causes of caries than the abnormalities in form which have just been considered. While hypoplasia, according to statistics compiled by Mr. Sidney Spokes,³⁵ is present in from 4.6 per cent. to 7.1 per cent. of the permanent teeth according to the class examined, irregularities in position such as may predispose to caries no doubt exceed 80 per cent. among adults in this country ;

and frequently the greater number of the teeth may, to a certain extent, be predisposed to caries in this way. The predisposition to caries, however, is not by any means always in direct proportion to the amount of the irregularities. Indeed, certain gross irregularities giving rise at places to practically complete stagnation, especially when there is a tendency for tartar to be deposited, do not, except in an indirect way (to be noted hereafter), predispose to caries. The irregularities which most surely induce caries are those which make the food consumed become lodged or impacted between the teeth. Nevertheless it may be said in general that "any departure from the normal arrangement favours the lodgment and stagnation of food,"¹ and consequently favours the onset of caries. Both abnormal relations of the upper to the lower teeth and abnormal relations of neighbouring teeth in the same arch are recognised to predispose to caries by inducing the stagnation of foods. Certain irregularities in the molar and premolar regions also tend to bruise the enamel and render it liable to rapid decalcification.²⁵ Thus when the level of the crown of a molar is distinctly below the level of its neighbour the approximal aspect of the higher tooth is almost invariably first and most rapidly attacked by caries, the thick rounded cusp of the lower tooth bruising the relatively thin enamel of the neighbouring tooth. The flat and relatively thin enamel nearer the neck of the tooth is readily bruised by the rounded part of the molar tooth lying against it when during mastication it may be subjected to a pressure occasionally amounting to more than 120 lbs.



The means at our disposal for preventing these irregularities may briefly be noted. Breast-feeding and general hygienic surroundings are important in being conducive to the normal development of the jaws and in the prevention of crowding of the teeth. This might be expected on general principles, but it has been statistically proved in an investigation by Mr. J. F. Colyer,^{9a} who has shown that breast-fed children of the better classes have broader arches than breast-fed children of hospital patients. No doubt this results from the more hygienic surroundings of the higher classes. He shows further that breast-fed have broader

arches than bottle-fed children. This would seem to indicate that the hygienic conditions or the nutritive quality of the food of the breast-fed children is more satisfactory than that of the bottle-fed. That it is chiefly due to the insanitary conditions almost necessarily associated with bottle-feeding is indicated by the fact that children hand-fed with bottles with rubber tubes (which cannot be properly sterilized) have still narrower arches than those who are brought up on the more modern, more cleanly and easily sterilizable teat attached directly to boat-shaped bottles. From Mr. Colyer's measurements it may at least be inferred that not only is attention to the general sanitary surroundings important in the prevention of irregularities resulting from crowding, but also that the more sanitary the feeding apparatus, the better are the jaws developed, and the results of his measurements seem to corroborate the generalization that the crowding of the teeth is in general proportionate to the ill-health or disease which may have existed during the development of the jaws.

Another point of some importance is the recognition of the early efforts of nature to secure correct antagonism or occlusion of the teeth. It seems probable that the instinct to gnaw more or less continuously during the coming into place of the incisor teeth indicates that the child should be supplied with a type of food which will allow and induce it most effectually to secure the correct occlusion of the incisors. In days gone past it was the custom to let an infant "cut its teeth" on a crust. It is obvious that gnawing such a foodstuff will tend to make the child habitually place its lower jaw in such a position that the incisors will occlude normally and the development of the jaw associated with this position and the effect of the tongue in moulding the arch will tend to bring about the correct occlusion of the incisors. The correct occlusion of the other teeth will almost invariably follow as a matter of course. From this time onwards food which stimulates efficient mastication develops the muscles of mastication, including the tongue, and correspondingly stimulates the development of the jaws so that crowding of the teeth tends thus to be prevented. This has been experimentally proved in rabbits by Dr. Laurence Baker,⁷ for by filing the teeth on one side of the mouth so that mastication could not be performed on that side, it was found that the bones of the jaw and indeed of the nose and base of the skull also, did not grow so perfectly as did the bones on the side on which mastication was performed. Similarly when from certain causes a child does not masticate effectually on one side of its mouth for a few years a noticeable difference in the size of the different sides of the jaws has been detected. More important than this, however, is the fact that chronic ill-health during the development of the child tends to prevent the normal development of the jaws, and recent observation seems to show that chronic ill-health and concomitant emaciation in children is largely, indeed almost solely, the result of a system of dietetics which has resulted in the foisting on children of all ages foods which leave the mouth in a state of chronic fer-

mentation. The constant swallowing of the fermented products, and associated bacteria, the diseased state of the gums and teeth, the absorption of poisons direct and indirect, are now recognised as most fertile sources of chronic ill-health. Foods of a firm and fibrous nature which stimulate the pleasurable activity of efficient mastication tend to keep the mouth and teeth clean and healthy. On the other hand, the soft foods which children are so generally compelled to consume do not clean the mouth, but leave it sticking with fermentable carbohydrates which no doubt constitute an excellent nursery for pathogenic bacteria, and induce a state of chronic fermentation which leads to the prolonged ill-health depicted in the pale and emaciated faces with ill-developed jaws and contracted arches of teeth so generally seen at the present day.

It is important also to prevent *mouth breathing* in children, because this is a fertile source of crowding of the teeth. To prevent mouth breathing it is necessary to prevent adenoids and associated pathological conditions. Adenoids may easily be prevented, as they result directly or indirectly in nine cases out of ten from cold and damp air. In the tropics, of course, and warm countries generally special precautions are hardly necessary, as cold and damp air is seldom present and neither are adenoids. In cold and damp climates, such as our own, statistics⁴¹ seem to prove that all that is necessary is to prevent the direct ingress of cold and damp air, more especially into children's bed-rooms during winter. (Some laryngologists now advocate that the door of children's bed-rooms should be kept open in cold and damp weather rather than the window).³⁰ To ventilate and warm chiefly by means of open fires and, if possible, to avoid damp localities and houses. Other conditions should be taken into account. Thus, excessive clothing of children leading to perspiration and chills, together with constant liability to catarrhal infections, say, at schools, especially when over-crowded and ill-ventilated, frequently results in adenoids. So too over-clothing and consequent perspiration at night in cold and damp rooms associated with too little clothing by day, may be presumed to have a like effect.

Subsidiary, though frequent, causes of irregularities, such as caries and the extraction or at least injudicious extraction of teeth, need not now be referred to; such extractions are not necessary when the requisite precautions for the prevention of caries are taken. To sum up, irregularities of the teeth may be prevented by bestowing ordinary attention on hygienic surroundings, by food which stimulates efficient mastication, and by rational ventilation. It may be thought that too little consideration has been given to the various steps between the actual predisposition brought about by the irregularities of the teeth—*i.e.*, the conditions favouring the undue lodgment of carbohydrate food—and the original remediable antecedent or condition which should not have been allowed to be present; but it is presumed that all subsidiary conditions which are necessarily correlated with the links briefly sketched out are obvious and recognised. Thus, though the chief links in the

chain between cold and damp air and irregularities of the teeth are indicated, mention has not been made of the fact that with regard to acute naso-pharyngitis, "exposure to cold and damp plays the chief exciting rôle," and that "exposure to cold really means lessened resistance of the tissue to germ vitality and germ entrance into the substance of the (mucus) membrane,"¹² that this leads to other catarrhal infections, and that the blockage of the nose arrests its development (von Ziem), yet the significance of these facts cannot be overlooked. Furthermore, although it is well recognised that the connecting links in the causation might be broken at some particular stage—thus adenoids may be removed by operation—yet necessary though this is when adenoids are present, the ideal method of prevention aims at avoiding the necessity for operation—in other words, the prevention of adenoids. Similarly when irregularities of the teeth are present they ought to be corrected.

THE PREVENTION OF RECESSION OF THE GUMS.

Recession of the gums is another predisposing factor in dental caries which, to a great extent, may be easily prevented, for this condition results largely from the stagnation of debris about the necks of the teeth. How this might be prevented by food of such a consistency as would act as a continual natural and inoffensive brush for the teeth and gums need hardly be referred to. It is recognised that teeth which are displaced in such a way as not to receive the natural pressure and strain of mastication are peculiarly liable to recession of the gums. Nor need the fact be mentioned that teeth which are constantly well used are more firmly rooted in the alveolar process, so that they do not become prematurely functionless through loosening. People who have teeth arranged in such a way that they are functionless become "long in the tooth," and those who do not put their teeth to the principal function for which they are so well adapted likewise become long in the tooth; so that the caries which we so frequently see in later life between and at the necks of the teeth is strongly predisposed to by the habitual use of food which does not stimulate efficient mastication. We may, indeed, say that after the gums have receded this predisposition to caries is the most important factor in its causation, especially when associated with irregularities.

It is the albuminous matter and the mucus, together with the salts it contains, lodging about the necks of the teeth, which is associated with or may induce tartar formation and infections resulting in recession. It is, therefore, important to note certain bacteriological considerations associated with mucus. It readily undergoes acid fermentation, but after a time the acid fermentation stops and putrefaction begins.²² A thin film of mucus bathed and miscible with saliva does not give rise, however, to such acid fermentation as would injure the teeth. If a piece of litmus paper be moulded over the gums and teeth it will be observed that just

at the junction of the gums and teeth the reaction indicates slight alkalinity, while the part which covers the gums indicates slight acidity. It is at these gingival margins that the mucus tends most to deposit, and if the deposit of mucus, together with the associated bacteria is thick, the deepest part more especially will most certainly have reached the stage of alkalinity. Here, however, that is, just at the gingival margins, complete stagnation of the mucus is not permitted, because there is a continual exudation of albuminous corpuscles from the gingival organ, and this, together with the exudation of a little serous matter, greater no doubt when mastication is vigorous, supplies the pabulum for the bacteria which liquefy and disintegrate the mucus and albuminous matter, thus keeping up a continual flux which normally prevents tartar formation. It is possible that these so-called salivary corpuscles by possessing chemiotactile properties may keep the space between the necks of the teeth and the gingival margin free from invading bacteria, while as they make their exit from the space they may also englobe bacteria and prevent masses of bacteria adhering about the necks of the teeth. Of course, if carbohydrates preclude the beneficent action of the saliva and are continuously lodging on this mucus and albuminous matter, which always contains numerous bacteria, caries may result along, or rather at some very slight distance from, the gum margin, though of course no physiologically correct diet allows this to happen. On the other hand, if the food which lodges is of an albuminous but non-detergent nature, then the mucus may not be sufficiently or frequently removed and ultimately may tend to allow of the deposit of tartar. As a matter of fact, we know that in such situations tartar is most frequently deposited, especially is this the case when from any reason mastication is more or less in abeyance together with the dependent and associated self-cleansing processes. Tartar does, of course, protect the necks of the teeth from caries, but it is an irritant to the gums and leads to their recession from the necks of the teeth; moreover, being an irritant it gives rise to a certain amount of exudation of albuminous plasma from the inflamed parts. This supplies the saprophytic micro-organisms with undue supplies of pabulum appropriate for their development, and thus further enhances the chances of infection of the gums by micro-organisms which tend further to destroy the gums. It has been found that almost pure cultures (*Spirillum Sputigenum*) may often be made from the bacteria associated with this hyperæmic state of the gums,²⁸ but it has been noted also that in such cases caries is conspicuously absent. From this it may be presumed that the micro-organisms associated with this condition are but feebly able, if at all, to decalcify enamel under such circumstances. Such conditions of the gums ultimately, however, give rise to recession and consequently to a predisposition to caries for the spaces that subsequently come between the teeth, become more and more remote from the hyperæmic gum and associated saprophytic micro-organisms, and such spaces are more and more liable to lodge carbohydrates. It is evident, therefore, that in order to control the forma-

tion of tartar the food must be of such a consistency as will stimulate efficient mastication and prevent the stagnation of mucus and consequently the undue proliferation of bacteria. It is suggestive and notable that all clean and healthy mouths contain bacteria, *e.g.*, *streptococcus brevis*, which is both acid-forming in the presence of all fermentable carbohydrates (*e.g.*, sugar, starch, lactose, maltose, glucose, dextrin)¹⁵ and liquefying in an albuminous medium. It would seem as if Nature had made a virtue of necessity, and being unable to exclude micro-organisms from the mouth altogether had turned them to good use. It is difficult to imagine a better method for the prevention of caries at these places where the friction of the food, lips, tongue and cheeks cannot thoroughly dislodge adherent mucus, for while it provides a slippery and protective coating favouring the easy washing away of foodstuffs, the bacteria incorporated in the mucus and albuminous matter (no doubt normally but slow acid producers) provide for the continual liquefaction and removal of the adherent mucus itself, together with all accumulations of debris, whether it be albuminous shreds or incipient tartar deposit. When we imagine what state the mouth would necessarily get into if there were no bacteria to liquefy albuminous food stuffs, or to disintegrate the film of mucus and help to dispose of or prevent the formation of tartar, we realize that the bacteria of the mouth appear to play a useful part as scavengers in cleaning it. We recognise how important it is that a method should obtain for keeping up a continual flux, thus preserving the teeth from destruction by acid on the one hand, and from the deposit of tartar on the other. Fortunately, both these objectionable results may be prevented by similar means, namely, a sufficiency of food which will stimulate efficient mastication, enough to ensure a fair amount of friction, and polishing of the teeth and a corresponding stimulation of the self-cleansing processes, to be more fully referred to later.

MUCUS AND SALIVA IN THE PREVENTION OF DENTAL CARIES.

Mucus is important as a lubricant and, mixed with saliva, a vehicle for the removal of food particles. It lubricates the mucus membrane and teeth on the one hand and the food on the other, thus facilitating the passage of the food from one part of the mouth to another during mastication, and finally ensuring its complete or practically complete removal from the buccal cavity. The mucus is secreted in amounts proportionate to the requirements of the particular kinds of foods for this purpose. Likewise the saliva facilitates the same physiological processes and the quality and quantity secreted is also proportionate to the requirements of the food consumed.⁸¹ Saliva has also a marked effect in preventing acids taken in food or developed by bacteria from decalcifying the enamel, and this effect seems to be much greater than could be accounted for simply by its power of neutralizing the acid.¹⁷ Mucus is freely miscible with saliva, so that even if mucus has no

similar power in protecting the enamel from decalcification it does not hinder such beneficent action of the saliva. The variations in the amount and quality of the saliva and mucus corresponding to the quality of the food consumed appear to be common to all, whether "susceptible" or "immune" to caries. That this is so is not a subject of controversy, but nevertheless the fact that the normal physiological processes supply with marvellous ingenuity the means of securing the cleanliness of the mouth and teeth seems to be most persistently overlooked by many who believe that the mouth is clean, or otherwise, according to whether it has or has not been brushed with a toothbrush.

Many now recognise that food demanding efficient mastication prevents caries on the masticating surfaces, but seem to doubt whether it has any such effect at the necks of the teeth. The following argument was recently put before me. It was contended that the food got into the crevices at the necks of the teeth after meals. It was admitted that it did so under abnormal conditions of the gums or if the food was of a sticky type. To this it was objected that it always must do so, for if a set of teeth mounted, say, on some substance to represent the gums were dipped into liquid, *e.g.*, water, and some coloured material, and then taken out again it would be seen that the water and colouring matter clung about the gingival margins and between the teeth. The reply to this was, of course, that such would certainly take place, but as the viscous mucus covers the teeth and crevices at the edge of the gums, much as the water would, that is to say, it would certainly be present between the teeth and at the gingival margins, and being adherent to the teeth yet slippery to the food, the food does not tend to lodge in such crevices. As a matter of fact if a normal mouth be examined after a meal not ending with fine, "short," specially lodgable foodstuffs it will be seen that food does *not* lodge in such situations. If, further, say a child (with normal and regular teeth and healthy gums) is given chocolate or toffee, and then the mouth is inspected a few minutes later, it will be seen that it is the crevices in the masticating surfaces which are specially liable to lodge such foods, and not the crevices of the gingival margins. Food is crushed down into the crevices of the masticating surfaces, and is not crushed down into the gingival crevices, but it slips past them. In the case of the interdental spaces, if any viscous foods or food particles get there, they are easily and effectually washed away with the saliva which is always passing between, at least if vigorous mastication is being performed, and the teeth and gums are normal in their relations, which, however it may be remarked, they seldom are in the neighbourhood of the wisdom teeth.

Before the rôle of the foodstuffs in the etiology, as distinct from the pathology, of caries was recognised, that is to say, before it was recognised that the chief factor in the causation of caries was the tendency of certain carbohydrates to lodge unduly about the teeth on the one hand, and that the chief factor in the prevention of caries was the tendency of certain other foodstuffs to brush fermentable carbohydrates away from the teeth, it was most generally assumed

that teeth decayed in some mouths and not in others, because of some unexplained susceptibility or immunity existing either in the substance of the tooth or in the secretions of the mouth. Dr. Black's investigation into "The physical character of the teeth"⁵ in relation to their diseases seemed conclusively to negative the assumption that susceptibility or immunity resided in the substance of the tooth, and gave rise to the idea that a thorough investigation of the oral secretions must reveal the cause of susceptibility and immunity. But numerous, and in some cases thorough though the investigations have been, it may certainly still be said that we have little or no knowledge of anything existing in the saliva or mucus which can account for the susceptibility to caries which is assumed to exist in some mouths.

Independent of normal variations in the saliva resulting from variations in the nature of the food and other physiological variations, there are occasionally abnormal variations in the saliva, and these variations do have an effect on the rapidity of the carious process no doubt. Thus, for example, diseases which eventuate in the arrested flow of saliva have been recorded, and diabetes may predispose to caries through the saliva containing glycogen. Such diseases should of course, be prevented or controlled. If disappointment is felt that we are able to say but little with regard to the constitutional variations of the saliva and mucus as predisposing factors in the causation of caries, consolation may be taken from the fact that in England, where the rôle of the foodstuffs in the etiology of caries is generally appreciated, the rôle of the saliva and mucus as predisposing factors are correspondingly felt to be of little consequence. And we do not now believe such statements, as for example, that "in the practical considerations of cases as they are presented to us when we have the care of families of children, the hereditary predisposition to caries is of the first importance."⁶ Yet this was the view which was held even by those who denied that the chemical composition of the tooth had anything to do with the predisposition to caries. Indeed, we now believe that the hereditary predisposition to caries resulting from the hereditary variations in the oral secretions is to all intents and purposes a negligible consideration, for it is admitted that what we took for hereditary predisposition turns out on more critical examination to have been similarity of environment.¹⁰ It had not been noted in this connection that similar dietetic habits ran in families and thus accounted for the *apparently* markedly hereditary nature of the disease. Similarly we are inclined to put little importance on the faint differences in the alkalinity or acidity of the saliva or slight variations in the amount of viscosity of mucus, when notwithstanding such variations we are able by altering the dietetic *regime* to make anyone practically immune to caries. If it be assumed that the dietetic *regime* alters the constitution in such a way that the saliva and mucus become healthier, and that in this way the change to immunity is brought about, then at any rate we have explained the necessary steps to be taken to prevent saliva and mucus causing caries.

THE PREVENTION OF CERTAIN DIETETIC HABITS WHICH TEND TO INDUCE DENTAL CARIES.

It is well to recognise that certain habits and preferences, if indulged in, tend to give rise to caries and may be prevented. Thus, for example, the bolting of lumps of food, which, by robbing the teeth of the natural detergent effect of such foods, ought to be prevented. This habit usually comes about in young children through habituating them to a more or less exclusively soft diet, in older children it has a like cause, often aggravated by tender or even decayed teeth. It is obvious that the teeth in these cases must be put right or got rid of by the dentist, and a diet consisting of food which stimulates mastication (*e.g.*, crisp toast, dry rusks, etc., and in older children apples, meat, nuts, etc.), allowed to form part of the meal. Other habits, such as eating sweets or farinaceous foods, together with milk on going to bed, must be simply stopped.

With regard to the habit of eating sweets and highly-sweetened foods, and the attempt to break the habit or the craving for such foods, more difficulty may be experienced, more especially if such habits and cravings have already been established. From an analysis of cases in which a large amount of food requiring mastication formed part of the daily *regime* it would appear that the desire for sweets originates to a certain extent from the habit of giving young children an almost exclusively soft diet, for in the majority of cases to be referred to, when the children were brought up on food requiring mastication, they seemed to prefer spending their spare cash on toys and not on sweets. In two cases under my own care the elder one (10 years) has never spent one penny on sweets, and the younger (5 years) only one penny (probably more for the pleasure of imitating his nurse than for the desire of eating sweets), but this has not occurred a second time, no doubt because the desire for toys exceeds his desire for sweets. In these two cases there was no injunction against buying or eating sweets (so long as they were not eaten between meals). The parents were what may be called notorious sweet-eaters in childhood. Other cases, although not so marked, seem to confirm the supposition that the craving for sweets varies in the manner indicated with the nature of the diet. Possibly such craving results from cheating the palate by the soft diet passing the palate quickly, while the amount of carbohydrate consumed can hardly be instinctively appreciated. No doubt, also, when children habitually end their meal with fresh ripe fruit they are more difficult to please with sweets, for fruits are sweet enough themselves and the aromatic flavours of fruits are but imperfectly imitated by the extraordinary chemicals which are incorporated with sweets to give them the flavours present in fruits. Moreover, if the adoption of such a type of diet will not stop the craving for sweets, there is no reason why the habit should not be stopped as far as possible by command. There are reasons for believing that in a natural state the supply of sugar was so limited that under such conditions an almost unlimited desire for it could not have been harmful. Nature supplied the restriction. In modern times it may be that parents must make the restriction if otherwise correct feeding does not prevent the desire.

The Prevention of the Immediate or Exciting Cause of Caries.

In our survey of the predisposing causes a general statement of the cause of caries was made which is now generally admitted, but it should perhaps be mentioned that a somewhat different conception of the cause of the disease was, and still may be, held. It is important to have an even more definite conception of the nature of the immediate or exciting cause when entering upon a consideration of the means to be taken for its prevention. Until recently it appears to have been assumed that the bacteria were to be regarded as the exciting cause and that meals containing fermentable carbohydrates supplied the pabulum necessary for the bacteria. That, in fact, except in the case of an exclusively meat diet, the carbohydrates in the meals always supplied the necessary and invariable conditions requisite for the micro-organisms to cause caries, provided only that the resistive forces in the tooth or in the saliva did not nullify or counteract the effects of the acid produced by the micro-organisms. Why, under such circumstances some teeth decayed in some mouths and did not decay in others was explained by assuming the existence of some unrecognised susceptibility or immunity. It was assumed as a natural corollary to this hypothesis that the rational way of preventing caries was to make the mouth as nearly as possible an aseptic chamber by the use of antiseptic mouthwashes. Nevertheless, in England, at least, it was held that what had been established was the pathology of the disease, and that the etiology or the cause of the disease remained an unsolved problem. The following three quotations will indicate the attitude which came to be taken up.

(1) "If we wish to deal with dental disease, we must first of all possess a correct knowledge of its cause. Do we possess that knowledge? It is now more than fifteen years since Dr. W. Miller's excellent work on the 'Micro-organisms of the mouth' appeared, in which he clearly demonstrated that caries of the teeth was due to the abstraction of the lime salts by acid, followed by the peptonizing action of bacteria, the acids being formed from the fermentation of carbohydrate food. There seemed to be a general belief at any rate amongst those practising dentistry, that the cause of caries had been found, and the fact seemed to be lost sight of that all that Dr. Miller had done was to demonstrate the phenomena of caries, and although his researches had shown the channels in which further investigation should be pursued, the actual cause of caries was still unknown, and is to the present day unknown."²⁰

(2) "In spite of Tome's classic definition of dental caries, and in spite of the researches of Underwood, Miller, Black, Leon Williams and others, we can no more tell why one mouth is immune and another riddled with caries than we could before these investigations were made."¹⁸

(3) "It is frequently stated that the true cause of dental caries has yet to be discovered, and that although we know the pathology of the disease through the investigations of Dr. Miller the etiology is a very different matter. The truth of this is obvious, and yet . . . nearly all the searchers after the etiology have pursued further pathological studies in their endeavours to discover it."²⁸

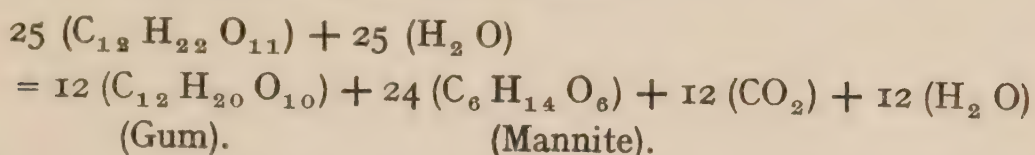
It is now generally recognised, however, that the fact of the prevalence of caries in some mouths and not in others (and all partaking of a mixed diet), is by no means necessarily a proof that there is any more susceptibility or immunity to the disease in the one case than in the other, for the idea has gained ground that some foods commonly consumed actually clean the teeth, while other foods more commonly consumed by children leave them sticking with fermentable carbohydrates, and that even the alteration in the sequence of foods—in one case finishing the meal with the detergent foodstuffs—may effect a profound difference in the lodging of carbohydrates consumed at meal times, and therefore in the prevalence of caries. This conception has been developed so far, that some now believe susceptibility and immunity in regard to dental caries is, if not a misconception altogether, at least an almost negligible factor which, at the present day, throws no light whatever on the means at our disposal to prevent the disease. Doubtless this is so, and no methods of preventing the unknown susceptibility to caries having been discovered or suggested, we must direct further attention to the means at our disposal for preventing caries by recognising that *the cause of caries depends on the prolonged retention or stagnation of fermentable carbohydrates in more or less immediate contact with the teeth and undisturbed by the free access of saliva*. It being unnecessary now to consider how this is influenced by the predisposing causes (these having been already referred to), it only remains to consider how the foodstuffs themselves are instrumental in preventing the onset of dental caries. For this purpose we may divide foodstuffs into two classes, namely, those which tend to leave viscous and fermentable carbohydrates about the teeth and those which tend to brush them away. When we observe what actually happens during mastication we see that it is chiefly food of a fibrous nature which stimulates efficient mastication. The more or less liquid part and suspended particles contained in the fibrous meshes are expressed and swallowed, while the fibrous part is again and again subjected to crushing and disintegration between the teeth. If an apple, for example, is thoroughly masticated the sweet juices are expressed and during the early part of the process these sweet juices are tasted. At the end of the process, however, the disintegrated fibrous mass is practically tasteless. The sweet carbohydrates and suspended particles are swallowed first, while during the process the more fibrillar part has been stimulating mastication, insalivation and dislodgment of food particles and bacteria. Similarly meat and potatoes or any of the common combinations of foods which are so naturally chosen and consumed by adults exhibit a similar phenomenon, but when we turn to the foods which children are at present

compelled to live upon very largely, *e.g.*, milk, porridge and milk, sloppy milk puddings, bread soaked in milk, potatoes and gravy, bread and jam, etc., we realize the absolute impossibility of efficient mastication being carried on. We realize further that what really is stimulated is simply a mechanical movement of the jaws which helps to plaster the sticky carbohydrates into the crevices of the teeth in which the bacteria—fed from previous meals and incubated in the intervals—are lying in readiness for the production of further quantities of acid destined to decalcify the enamel of the teeth. Hitherto, as has been noted, it was customary to regard bacteria as the exciting cause of the caries, but when we consider the fact that it is only when carbohydrates are made to lodge unduly with the ever-present bacteria that acid is produced, we might perhaps with greater propriety say that it is the carbohydrate which is the exciting cause. Indeed, this is now very frequently done, for it is only when carbohydrate lodges unduly that the micro-organisms are excited to acid fermentation. Moreover, if no carbohydrate lodged in the mouth the bacteria which are best adapted for that medium would be present only in innocuous numbers—probably many species would be prevented from proliferating in the mouth altogether—while the bacteria which find in the albuminous desquamated epithelium and other proteid substances their natural foods might actually be antagonistic to the presence of acid-forming and possibly also to pathogenic bacteria. Still keeping to the view that the bacteria are to be regarded as the exciting cause of caries we recognise that the foods control the bacteria.

(1) Fibrous foods which stimulate efficient mastication clean the bacteria out of the mouth altogether to a great extent. This is obvious, but to make assurance doubly sure I made some experiments which resulted in showing that a given quantity of toast chewed before breakfast, then set aside in an incubator, developed acid much more rapidly and in much greater amount than an equal quantity of toast similarly chewed after breakfast. A similar result, including not only the relative but also the absolute quantity of acid produced, followed the same experiments with stone-milled flour (bread toasted). Most foods being practically sterile do not introduce bacteria into the mouth.

(2) Fibrous foods which, by stimulating mastication, remove sticky carbohydrates, remove also the nutriment which is most necessary for the development of bacteria most active in a carbohydrate medium, *i.e.*, (a) acid-forming bacteria, and (b) bacteria which give rise to viscous fermentation. This latter class of bacteria is often overlooked, but inasmuch as it is only when the acid formed by bacteria is protected from neutralization or dilution with the saliva that decalcification of the enamel results, it is obvious that viscous fermentation must be reckoned with and should not be allowed, much less encouraged in the mouth. Thus, therefore, cane sugar when not sufficiently diluted or eaten with something of a detergent nature may possibly under certain circumstances be more destructive to the teeth than the more directly fermentable sugars.

The formula which is given³⁴ to represent the conversion of cane sugar into mannite and gum is as follows :—



With regard to the fermentation of the grape sugar groups and the cane sugar groups Miller comes experimentally to the conclusion that “the one is apparently about as detrimental to the teeth as the other.”^{23b} Probably this results from the fact that in a mixed bacterial culture such as we have in caries, some bacteria are inverting the cane sugar while others at the same time are producing acid from the inverted sugar. It would be a mistake to argue that because some species of bacteria cannot convert cane sugar that it is less harmful to the teeth than the grape sugar, because it is not pure cultures which have to deal with the sugar in the mouth.

As has been indicated in the preceding pages, foodstuffs reduce the number, and probably also the number of species, of the micro-organisms of the mouth, and as it has been maintained that one of the most important methods of preventing caries is as far as possible to sterilize the mouth, it may be as well to note that the sterilizing of the mouth cannot be regarded as a *natural* means of preventing the disease. While, therefore, by no means claiming that the mouth could be sterilized, we may at least say that the foodstuffs can control the micro-organisms so effectually that the teeth of civilized man may be as clean and free from caries as are the teeth of the lower animals, or certain savage races which do not use any artificial methods of cleaning the mouth. Further, we recognize the useful part which, when controlled, these micro-organisms may play. It is significant that there are no antiseptics naturally present in the mouth, and moreover, that the bacteria of the mouth are as constantly present in the mouths of susceptibles as immunes. Dr. Miller has shown that the number of bacteria is almost as great in the *saliva* of “immunes” as in the *saliva* of “susceptibles,” and that acid production by the bacteria, though slightly greater in susceptibles than in immunes, is so only as a rule.²⁴ Similarly *leptothrix innominata*, which “invariably occurs in every mouth, though by no means always in the same numbers”^{23a} lends no support to the view that the constantly present bacteria necessarily induce caries.

Dr. G. V. Black comes to a similar conclusion: he says “As I have cultivated micro-organisms a great deal, and especially in relation to this matter, I wish to say distinctly that the same micro-organisms are found growing in the mouths of persons who are immune to decay, as are found in the mouths of persons who are susceptible to decay, and those whose teeth are decaying rapidly, and the same micro-organisms will grow in the saliva of either one when used as a cultivating medium.”⁴ We see from this that to call the micro-organisms of the mouth the cause of caries would

throw little or no light on the means of preventing the disease, and we are driven to accept the definition of the cause of caries already given.

NORMAL SELF-CLEANSING PROCESSES.

The normal or natural self-cleansing processes are generally recognised to exist, but they are seldom studied or described, and yet it is by recognising the nature of those self-cleansing processes that we are enabled to indicate scientifically what natural or artificial means may best be relied upon for the prevention of caries. The consideration of these processes with regard to artificial methods of cleansing will be referred to hereafter ; in the meantime it will be well to recall certain points in natural oral hygiene (more especially with reference to the nature of the foods consumed) for, however simple it may be to arrange dietaries in such a way as to secure physiological cleanliness of the mouth, it is highly desirable to recognise the main features of the normal and natural processes by which physiological cleanliness is maintained, however complex these processes may be. For convenience in description we may consider the processes under different headings, although they are more or less intimately associated and dependent upon each other.

Firstly, we have the *mechanical* process. This depends, to a great extent, on the physical consistency of the food. When the food is of a firm and somewhat fibrillar consistency, it stimulates the pleasurable activity of efficient mastication. The teeth and gums are rubbed and scoured, particles of food are dislodged from the teeth, expressed from the bolus of food, entangled in the mucus saliva and sucked or pressed back towards the pharynx, and swallowed. In other words, food of such a consistency has a detergent effect. Highly refined or "short" and soft food has, on the contrary, a different effect when taken into the mouth ; it is simply crushed or squashed into the crevices of the teeth, and, if it is at all of a sticky nature it remains impacted there. Bread and jam and cake may be taken as examples of such foods which tend to lodge about the teeth.

Secondly, we have the *chemico-physiological* process. Food, when taken into the mouth, stimulates a flow of saliva, and carbohydrate food, especially if slightly acid and firm in consistency, stimulates the secretion of saliva rich in ptyalin. The mastication helps to incorporate the ptyalin in the food, and the solid starch becomes partly converted into soluble sugar, which is ultimately expressed from the more fibrous part of the food and swallowed in a liquid or nearly liquid form. The more fibrous part is subjected to further mastication and lubrication with mucus before swallowing. This is, of course, the natural method of treating carbohydrate food, and, in passing, it may be said the physiological method of leaving the mouth free from carbohydrates at the end of a meal. It should be remembered, however, that much sugar hampers the action of the ptyalin.

Thirdly, we have the *hydrodynamical* process. With each act of mastication, the saliva is mixed with the food, forced in certain directions, between and about the teeth, between the food shreds, and ultimately it, together with dissolved and suspended particles, is swallowed. We may note here again, that if the food is soft and pappy, this hydrodynamical process is practically lost, as such foods do not stimulate efficient mastication. Lastly, we have a *saprophytic* or *bacterial* process. In the whole history of man or animal, the mouth has never been free from micro-organisms, and the bacterial flora of the mouth seems to play a part in its hygiene. There is no pepsin or other ferment in the mouth which can digest or liquefy the various albuminous shreds and particles which are apt to lodge between the teeth. But there are many of the mouth bacteria which have this power. In fact, these bacteria digest and liquefy the albuminous shreds which lodge about the teeth, and so allow of their dissolution. They give rise to a continual disintegration and removal of food particles, and tend to keep the teeth clean at those very situations which are not kept clean by the natural friction of the food, tongue and lips. It cannot be said that all the bacteria which may be in the mouth are beneficial under all conditions, for even some of those which have the power of liquefying albuminous matter have also the power of producing acid when the lodging food particles are of a starchy, viscous or sugary nature. The strictly liquefying mouth bacteria, however, seem to be quite innocuous to the teeth, and if the dietary is arranged physiologically, these beneficial mouth bacteria are favoured, while on the other hand, the harmful—the more pronouncedly acid-forming bacteria—are, in my opinion, at least, prevented from proliferating. This might be considered an obvious deduction from the fact that the kind of bacteria which proliferates best is that which is appropriate to the given medium. But it is not merely a deduction, for Mr. K. Goadby has observed that the number of putrefactive rather than the acid-forming bacteria preponderate in the mouths of Zulus and Kaffirs with good dentitions and also in monkeys, and this seems to result from methods of living which favour the cleaning away of fermentable carbohydrates.

In perfect mouths no doubt bacteria for cleansing purposes are but little if at all required, for the mucous membrane comes up nicely over the necks of the teeth, finishing off almost like a fine film closely applied to the neck of the tooth, so that the gum margin and tooth present hardly a visible crevice where food debris could lodge. When also, together with such arrangement of the gum margins, the teeth are perfectly regular and well formed, extremely few food shreds or particles are likely to lodge after any physiologically correct meal. Such perfect conditions should exist in the great majority of children at least, for in those children to be referred to later, who were dieted physiologically, the conditions referred to remained practically perfect.

While recognising the beneficent role of physiologically correct meals, it may also be noted that together with the foods taken at meals there are also generally a number of adventitious bacteria

taken into the mouth, especially after eating certain kinds of food, *e.g.*, cheese. They may remain there for some little time, but they do not appear to hold their own in the mouth, what are called the mouth bacteria, being more adapted for the environment. Those adventitious bacteria are gradually swallowed till in a short time none are to be found in the mouth. Dr. Miller has shown experimentally that even bacteria, which can hold their own for a time when added to saliva, are, when taken into the mouth, rapidly got rid of from the mouth. Thus after rinsing the mouth thoroughly with a bouillon culture of *Bacillus prodigiosus* containing over 2,000,000,000 bacilli, so as to give them a good chance of establishing themselves, he found an astonishingly rapid decrease of bacteria, so that at the end of four hours the *prodigiosus* had disappeared from the mouth. Thus while adventitious bacteria find their way into the mouth they are rapidly got rid of, while the mouth bacteria remain and proliferate with such tenacity that, as Dr. Black's extended research shows, about twelve species are practically constantly to be found in the mouth if diligently searched for. This number is augmented in some mouths, for if abnormal conditions exist in any month, bacteria appropriate to the abnormal environment are not long in finding the suitable nidus for their existence and development. The mouth is so exposed to bacterial infection that whenever it presents a suitable soil for the development of any common species of bacteria, then such bacteria will gain a foothold, and without such suitable soil it seems impossible for any species of bacteria to have more than a transient existence in the mouth.

It may be mentioned here that a bacteriological method for the prevention of caries has been suggested.¹⁴ It consists in endeavouring to sow some adventitious bacteria in the mouth which will be antagonistic to or crowd out the (acid-forming) bacteria already present. As this method is accompanied by regulations regarding artificial cleansing and the use of lotions antagonistic to the development of acid-forming bacteria, and is then followed by regulations as to diet, and as the results have not and cannot be claimed to be better than the results which have been obtained even from regulations in diet alone, it would be difficult to say that the bacteriological procedures have anything to do with the good results which have been claimed by its author. Moreover, the method seems only to be applicable after caries has actually manifested itself, and so can hardly be considered satisfactory. The suggested method has much interest, however, in showing the different attitude of bacteriologists towards the bacteria in the mouth, from that which existed in the days when antiseptics and artificial brushing were the sole methods relied upon for preventing caries, and when attention to diet and dietetics as a means of preventing decay found no place in our text-books on dental surgery.

Diet in Infancy and Childhood in Relation to the Prevention of Dental Caries.

The diet in infancy and childhood may be considered at three stages. Firstly, the diet of the toothless infant. This should be mother's milk, and as there is unanimity upon this point, all that is necessary to advocate further is that investigations into the causes of deficient lactation in women should be made, for it seems certain that the substitution of other kinds of milk and all means to find a perfect substitute must always remain unsatisfactory. The second stage to which it is necessary to direct attention is one of transition, transition on the one hand from the toothless infant to the child with a complete set of temporary teeth, and on the other from the milk diet to the solid and varied diet for which the child's teeth and alimentary canal are so admirably adapted. This period of transition is most important. It will be remembered that while "the child starts life edentulous and gradually acquires teeth, other parts of the alimentary tract in the healthy subject undergo concordant changes."³⁷ Now for the first six or nine months of a child's life it has been accustomed to extracting liquid from the mother's breast, and through all the ages of man's evolution nothing was mixed with this milk. When, with increasing age and concomitant changes the first article of food was presented to the child it was given at a different time from the sucking of the milk. It must be obvious that in a state of Nature it was utterly impossible to soak food in milk in order to effect the transition from mother's milk to the ordinary foods of children and adults. Moreover, there is no precedent which could in any way be interpreted as justifying the method of transition from milk to solid food which has been so universally adopted by the medical profession. How the transition from milk to solid food is recommended may be exemplified by a few extracts from a recent authoritative text-book published "to aid the young practitioner" of medicine. After nine months, the author says, "Dilution of the milk is not necessary. . . . Some solid food may be added in the shape of boiled bread, or porridge, or pudding. These additions must be small in quantity at first." Then when the child is twelve months old, he says, "The porridge may be made thicker and of coarser oatmeal. A little potato and gravy or half an egg may be given once a day. Soft bread and butter or dripping may be taken."^{38a} A transition from milk to solid food such as is exemplified in the above, never existed in the evolution of man or animal. For simplicity attention may be limited to bread soaked in milk, for it illustrates the pap feeding principle as well as anything else, and it is the most generally recommended food for infants who are beginning to be allowed something solid in addition to milk. Now what happens when an infant hitherto accustomed to milk is given bread well soaked in milk? The first noticeable effect is that the infant gulps down the milk-soaked bread and milk without any attempt at retaining it in the mouth or mixing it with saliva. The starchy matter in the bread is, therefore, washed into the stomach.

without any insalivation, without any conversion of the starch, and without any preparation for digestion in the stomach. The physiological effect which the retention and mastication or gnawing of food in the mouth produces is practically lost, and the flow of digestive juices in the stomach is correspondingly lessened. The palate is cheated, for large amounts of carbohydrates are washed rapidly past it, and instead of appreciating the amount of converted starch, or rather of unconverted starch, which the child has consumed, it craves for more of that very substance of which it has already consumed too much, in other words, it develops an abnormal craving for sugar. Further, by becoming habituated to swallowing solid food it soon loses that automatic mechanism which arrests solid food in the mouth till it has become liquefied and prepared for deglutition.

At a later stage, say, about the thirteenth month, when the first temporary molars have taken their positions, what happens when the child is restricted to this soft diet? The previous troubles continue and the teeth get dirty and tender from want of use; later they become carious and the tenderness increases, while for the same reasons mastication is not performed, and so these troubles and others resulting therefrom become more or less thoroughly established.

But it may be asked, Why, then, has the milk-soaked diet been brought into existence? Well, no doubt it is because milk was considered the most excellent food for children. But it was found that cow's milk, when it was given to children undiluted, formed large clots in the stomach and thence consequently led to various intestinal troubles. This did not dissuade those in authoritative positions from still advocating undiluted milk. No, they said, soak bread in the milk so that the clots will be broken up. And if there is choking and spluttering see that it is thoroughly soft and well broken up before the child gets it.

Now why should a hint not be taken from Nature? Mother's milk when the child reaches nine months or a year does not become more solid, rather the reverse. Suppose we give cow's milk, why should we make it less diluted than it was before, seeing that the time is beginning to approach when the child will and can eat solid food and drink liquid water? The child has been accustomed for all the months it has existed to have its mother's nipple in its mouth (or an artificial substitute), and from this it has been able to express or suck liquid food. When it is determined to give the child solid food, why not let it get a solid piece into its mouth? In other words, why not let it have a slice of bread, or better perhaps, toasted bread and butter? No doubt the child feels that toast and butter is not its mother's breast, and it certainly subjects the toast to the influence of its teeth. It gnaws it and sucks it; the gnawing induces a flow of saliva and the ptyalin converts the starch. The child continues to suck much as it sucked its mother's breast, and its palate appreciates that it is actually sucking liquid out of the solid toast. Gradually the toast disappears, practically in the form of liquid down the child's throat, thoroughly prepared

for further digestion in the stomach. Before the fourteenth month, or at least before the first temporary molars erupt, true mastication, of course, is not performed. It is gnawing which is indulged in, and it certainly and instinctively is indulged in by all children. After the child has had its toast to supplement its milk diet, say, twice a day for a month or two, then other things may be added, such as rusks and milk puddings made sufficiently solid, and as there is not an excess of albumen in the milk (it having been diluted), boiled fish and chicken may be given in small amounts.

I have had some little experience with this method of feeding infants, and can say most unhesitatingly that coughing, choking or spluttering has been conspicuous only for its total absence. And those who have adopted similar methods with children from the beginning have been impressed or even astonished by this fact. But this is not all, the desire for hard food remains. The teeth do not become tender nor the mouth dirty nor the teeth carious. The palate is not cheated, and the desire for excess of food or sweets does not exist. The alimentary canal performs its functions in a natural and healthy manner, and by the age of $2\frac{1}{2}$, when it has its full set of temporary teeth, the child can and may be allowed to triturate practically any food which adults habitually eat.

With regard to the third stage, that is, the diet of children after they have their twenty temporary teeth, but little need be said here. The principles on which it is based, however, are the result of careful enquiry, experience and a study of the evolution of man and his diet, together with a recognition of the needs of civilized life.

It should consist of three meals daily, and nothing between meals except water when desired.

It should contain a sufficiency of solid food of a consistency which will ensure thorough cleansing of the teeth by the food and stimulate the pleasurable activity of efficient mastication so as to prevent the child acquiring the habit of bolting its food. Different ways of doing this will no doubt suggest themselves, but perhaps the simplest way is to have toast, baked bread, or crusty bread rolls instead of plain bread or porridge.

Lastly, the meal should be *arranged* physiologically. All that need be said at this point, however, is that the meal must not terminate with concentrated and easily fermentable carbohydrates which lodge or stick about the teeth. Thus, therefore, no meal should end with bread and marmalade or jam, nor should it end with sweet milk puddings or foods with a large amount of sugar. If these things are eaten they must be followed by fresh fruit, and of all the fresh fruits which clean the mouth and teeth the apple is the best.

The nature of the diet after the child has a complete set of temporary teeth is of so much importance that, in order to indicate the exact nature of the methods and principles of dietetics involved and the various reasons for advocating them, it may be well to mention a few points in the history of the investigations which led, as far as I am concerned, to the advocacy and adoption of the methods.

The Natural Hygienic Method of Preventing Dental Caries and Reasons for Insisting on its Adoption.

About twenty years ago circumstances had caused me to become keenly interested in the problems of heredity, and rightly or wrongly I came to be a firm believer in the then new doctrine that acquired characters were not inherited, and *a fortiori* that mutilations were not inherited. Equally was I opposed to the Lamarckian doctrine, that use and disuse of any organ had an effect on the hereditary potentialities of such organ. These being my beliefs, it was impossible for me to subscribe to the dictum that dental caries was so markedly hereditary that no one would even suggest the contrary. To me the theory of the hereditary degeneracy of the teeth was unthinkable, and from the point of view of prevention it was absolutely useless. But just because the hereditary view was untenable so much the more was the true solution of the problems of causation important, for if the etiological factors were essentially environmental, then this it would be in our power to alter for the better. Nor did the various developmental theories appear to help much in the solution of the problem, for although certain facts, such as the elimination of phosphates from bread, seem to offer a plausible explanation of the generalized augmentation in the amount of caries, nevertheless the fact did not in any way account for the prevalence of the disease in certain families and its absence in others, which equally consumed the same bread. Moreover, the fact that less phosphates are absorbed from wholemeal bread¹⁶ than from white bread absolutely negated this view. The theory that in districts where the water is deficient in lime salts there was more caries than in districts where the lime salts in water were abundant, did not in any way account for the increased prevalence of caries in the same district, nor for the variable amount of caries in any one district. Moreover, it was not my experience that the amount of caries did vary with the proportion of lime salt in the drinking water. Still one other developmental theory had to be considered, namely, the theory that the soft nature of our civilized foods gave rise to a type of tooth which was specially liable to decay. This seemed to me quite untenable, because the crowns of the temporary teeth, which are so "susceptible" to decay, are formed partly before birth and completely before the child has left off sucking liquid milk. It became apparent that the then prevalent theories would not bear analysis. We had all the facts at our disposal, which utterly condemned such theories as we have referred to. We had, indeed, too many facts which, for want of a correct theory, seemed only to confuse investigators and make the subject appear more hopelessly complicated. There seemed to be only two ideas which appeared to contain a germ of truth. The first was the once popular belief

that sugar was bad for the teeth. Now, although this idea probably had originally no better foundation than that children with carious teeth frequently brought on toothache by eating sweets, yet the idea was not antagonistic to the pathology of the disease, and what is of more consequence, it seemed on the whole to be supported by facts which were frequently brought before us in our routine practice. It is true that the amount of caries was by no means constantly related to the amount of sugar consumed. Moreover, occasionally cases cropped up which appeared to contradict the hypothesis, and nothing is more destructive to a theory than demonstrable facts which cannot be made to harmonize with it.

It was pointed out that children living in sugar-cane plantations and chewing sugar-cane for many hours a day were remarkably free from caries and this supplied a generally accepted fact which more or less expunged the sugar hypothesis among the educated classes. The second idea which appeared to contain a germ of truth was the relation between attrition of the teeth and freedom from caries. This was also a general statement and was not always true in particular cases, or even in particular races ; still, in general, it was admittedly true. We see, however, that neither of these hypotheses seemed to be of practical value, because in the same country and under supposed similar dietetic *regime* we found a considerable percentage of people with perfect teeth, and also a large number with their teeth most hopelessly ravaged by caries. Indeed, the question of the food in relation to the prevalence of dental caries gradually came to be regarded among dentists as an untenable theory, while the supposed *susceptibility* of some and *immunity* of others became an accepted fact, and the solution of this problem of susceptibility and immunity became the all-important and all-absorbing subject among the prominent and thoughtful members of the dental profession. Notwithstanding all this, however, there was a lurking belief that although nothing had been found in the modern foods which appeared to help us to solve this problem of why some teeth were ravaged by caries while others were perfectly free from the disease, yet I had hope that a more thorough investigation into the foods and dietetic habits of the "susceptible" and of the "immune" might throw some light upon the subject. It was necessary to have some hypothesis, of course, to direct one's investigation to profitable account. Indiscriminate search, however scientifically tabulated, seemed to me to offer little hope of doing anything but making confusion worse confounded. In my preliminary investigations many hypotheses were made and were successively more or less completely killed by the facts which were revealed. Still certain things became apparent, and one was that the diet and dietetic habits of children in the same country, even in the same districts, differed considerably ; another was that what might be considered natural foods as opposed to the highly refined or artificially prepared foods, were consumed in quite different quantities by different people. These early investigations and a knowledge of the pathology of dental caries led me to investigate whether the refined foods

of the present day might be more lodgable than the less refined and less prepared foods of past ages. An investigation into the relative lodgability of the various foodstuffs in the crevices of the teeth was therefore undertaken. I made about 600 observations in one month after meals and found that the "short," highly refined carbohydrate foods tended to lodge unduly in certain crevices about the teeth, while the foods of a more fibrillar or fibrous character did not tend to lodge in such situations so readily. Indeed, it gradually became apparent that the more fibrous foods had a detergent effect, that they stimulated efficient mastication and consequently might be presumed to prevent the undue lodgment of bacteria and mixed foods which were known to give rise to acid fermentation and to the destruction of the teeth. The crevices in the teeth of the mouth referred to were abnormal and contained fillings, so that it was necessary to verify all such observations in other mouths. It consequently has been my practice for the last ten years or so to inspect the crevices of all children's teeth immediately they sit down on the dental chair, and then ask them what they had eaten last. Moreover, with two children constantly under my observation, I have been able to vary the foods at pleasure and observe the lodgability of any particular food or the detergent effect of any particular food. In these ways a vast number of observations have been made which taught me that some foods are likely to lodge about the teeth and cause caries, while other kinds of foods tended to clean away lodging foodstuffs and therefore to prevent caries. This hypothesis also received general confirmation from an investigation into the state of the teeth of savages, for it was found that the amount of caries varied inversely with the coarse and fibrous nature of the foods. The relative freedom from caries among those people and races whose teeth had undergone attrition still further corroborated the theory, and furnished an explanation of the fact that the teeth of children who chewed sugar-cane were relatively free from caries, for sugar-cane is a highly fibrous foodstuff and detergent in its effects, while the sticky sweets consumed by civilized children are not detergent and therefore induce caries. On reconsidering the subject it was evident that the refined foods of the civilized were even more nutritious and more easily digested than the foods of the savages, so that we had no ground *whatever* for the assumption that the teeth were deprived of nourishment or lime salts or anything else which would injure their development. Moreover, it became evident that the chief chemical change in the foodstuffs was a decreased consumption of the carbohydrate known as cellulose, and the chief physical change was also to be found in the refinement and softening or elimination of the cellulose. We may now refer to some of the general changes which the food of civilized man has undergone since he emerged from the savage state.

Cellulose in the natural or uncooked state is, as a rule, of a consistency which stimulates vigorous mastication, but in civilized countries the cellulose is cooked, softened and often altogether extracted from the food, so that the detergent effect which this has

in its natural state is almost completely lost. Indeed, it may be presumed that in the state in which it is frequently presented it helps to clog the crevices rather than to brush away the bacteria and fermentable food particles which may lodge about the teeth. In fact, the absence of cellulose in a form which should stimulate the pleasurable activity of efficient mastication practically nullifies the mechanical, the hydrodynamical and, to a certain extent, the chemico-physiological self-cleansing process of the mouth.

The next carbohydrate to which we may briefly refer is *starch*. This, when cooked or boiled, becomes of a pasty nature, and it is easily converted into sugar, which becomes rapidly fermentable. Starch, therefore, when taken in the food, unaccompanied by food of a detergent nature, is eminently fitted to lodge and undergo acid fermentation in the mouth.

Lastly, we may refer to *sugar*. Sugar has long been supposed to have a deleterious effect upon the teeth. The investigations of Miller, however, tended to show in his opinion that it was to be considered as less harmful to the teeth than starch, and the fact, or at least the supposed fact, that children who consumed large quantities of sugar from the sugar-cane were relatively free from dental caries gave rise in the minds of most dentists to the idea that the "sugar-bogey" had been slain. And although most would admit that neither starch nor sugar could be beneficial, there was, of course, little use of talking about preventing children eating both sugary and starchy foods. Miller based his criticism largely on the fact that sugar was readily soluble and was, therefore, "soon carried away, or so diluted with saliva as to be rendered harmless." Clinical evidence, however, supports the idea that the sugars are more harmful than the starches, no doubt from the fact that in addition to inversion cane-sugar undergoes a mannitic fermentation, forming a gummy substance which not only clings about the teeth, but also tends to catch other particles of food, and to retain them in contact with the teeth also. Secondly, sugar hampers the action of the saliva, and lastly, the method of eating sugar in the form of bonbons causes a continuous supply of this fermentable material to be available for the acid-forming bacteria lodging in the crevices of the teeth. With regard to the relative excellence of the teeth among the natives in the sugar-cane plantations, this is, of course, largely due to the fact that the fibrous cellulose of the cane stimulates the self-cleansing factors most thoroughly.

Whether cane or grape sugars are the most harmful does not appear to be definitely settled; it seems pretty certain, however, as a clinical fact that sugar as usually consumed, sweets, marmalade, jam, etc., is markedly harmful to the teeth. I can imagine someone saying, "Well, perhaps these changes in the foodstuffs referred to may account for the increased prevalence of dental caries in a general way, but do these changes account for the great variation in the amount of caries which we see in different mouths at the present day?" We see many children, for example, with almost every tooth more or less carious before they are more than five years old. On the other hand, we occasionally see children of the same age

with every tooth free from any trace of disease, yet all have been brought up in the same country and the changes in the foodstuffs are common to all.

Now it was these very groups of cases which used to fascinate me most. It was, indeed, these extreme cases that first made me come to the conclusion that the dietetic habits of the children with the perfect teeth were essentially different from the dietetic habits of those with the bad teeth.

We may illustrate the two different types of diet which are often more or less consistently followed by the following dietaries :—

Firstly, we shall refer to the kind of meals which do not produce caries :—

Breakfast. Fish, bacon, toast and butter, coffee and tea.

Luncheon. Meat or poultry, potatoes, salad, baked bread, pudding, fresh fruit, water.

Supper. Rusks, toast, or bread rolls and butter, chicken or fish, an apple, tea or coffee.

Secondly, we may outline the kind of meals which induce dental caries :—

Breakfast. Porridge and milk, bread and marmalade. Then perhaps a supplementary breakfast a few hours after of a glass of milk and a sweet biscuit.

Luncheon. Mashed potatoes and gravy, or minced meat, milk and pudding.

Supper. Bread soaked in milk, or bread and jam, cocoa and cake, and a supplementary supper on going to bed of a glass of milk and a biscuit, or just "a tiny piece of chocolate."

On comparing these two different types of diet, we observe that one is of a kind which stimulates mastication and the last thing taken leaves the mouth clean, or at least free from carbohydrates, so that even when soft food is part of the meal the mouth will be physiologically clean at the end of the meal. The other type is intended to represent the kind of meal which is calculated to lodge about the teeth and to ruin them within a few years by making efficient mastication and the self-cleansing of the mouth practically impossible, and by leaving the mouth sticking with fermentable carbohydrates and a virulent crop of acid-forming micro-organisms which have had their development encouraged by the previous meal.

Since discovering, about ten years ago, the general type of diet which gave rise to caries, it has been my custom to question all children carefully about their diet, if their teeth were free or practically free from caries, and in *every* case it was found that the food habitually consumed was of the detergent type, or, if not altogether so, at least that it was consumed in such a way as to leave the mouth physiologically clean at the end of the meal; I cannot tell exactly now how many children I have examined with perfect teeth. The number probably does not amount to fifty, for perfect teeth are very rare in England. One thing is certain, however, I have

not yet seen one single child where the teeth were perfectly free from caries which was not brought up on a type of diet such as I have indicated does not produce dental caries. On the other hand, many mouths were seen devastated by caries, and I have certainly seen several hundred such mouths, but in these cases the type of diet habitually consumed and the dietetic habits engendered have invariably been such as result from the caries-producing type of diet which I have illustrated.

This is a brief outline of the somewhat prolonged investigation which has, in my opinion, resulted in a solution of the problem of the prevalence of dental caries and for the assertion that susceptibility and immunity is almost invariably *assumed*, through lack of knowledge of the cause as distinguished from the pathology of the disease. I have tried to indicate some of the evidence upon which the theory was based and the evidence also which corroborated the theory. It now only remains to bring forward even more startling evidence, and to make it more obvious to those who did not or would not take the trouble to follow the facts and arguments which demonstrated the truth of the theory. It appeared to me that the most satisfactory way of doing this would be to get people with infant children to put the theory into practice. Fourteen children have been subjected to this test, and at ages ranging from 5 to 7 years their teeth were examined, with the result that not one tooth of any of these children showed the slightest trace of caries. This may not seem a large number, but when we remember that in England a similar number of children of the same class would certainly have had eighty to ninety carious teeth among them at the same age, we see that according even to this alone there is overwhelming probability or practical proof that the theory is correct. Over and above this we must remember that this application of the principles of prevention is but a small part of the evidence which has enabled us to prove the truth of the theory.

Artificial Methods of Preventing Dental Caries.

There are several different procedures which in practice are usually combined in cleaning the teeth artificially. It will be convenient, however, to consider these under different headings, while bearing in mind that certain combinations are frequently to be preferred to any one artificial procedure.

MOUTHWASHES.

The simplest and most inoffensive artificial procedure is the rinsing of the mouth after meals with water. It is well when explaining the value of this, to tell patients to observe the water which is ejected from the mouth after rinsing it about the teeth, for by the disappearance of the milkiness of the ejected water they will be able to see and appreciate how much has been washed away by this process. Several mouthfuls of water may thus be used until the ejected water comes from the mouth practically free from milkiness. The efficacy of such a mouthwash depends on its simple mechanical or rather hydrodynamical effect on the more or less loose remains of foodstuffs and bacteria. The usefulness of the mouthwash may be enhanced somewhat by the addition of aromatic flavourings which not only may be made to leave the mouth with a pleasant and cleanly feeling, but also will stimulate the salivary secretion and thus prolong the action of the washing-out process with the natural mouthwash. A slight acidity in the mouthwash is also beneficial in stimulating the flow of saliva, and though it may be very transient and slight, the effect of the acid on the mouth bacteria should tend to inhibit the growth of the micro-organisms, more especially the acid-forming micro-organisms.

ANTISEPTICS.

The mouthwashes may also be made antiseptic. Much good was at one time expected to be derived from their habitual use, but this arose no doubt to a certain extent from mistaking the pathology for the etiology of the disease. At all events, the prevention of the undue lodgment of carbohydrates was not the aim or object of antiseptics. The fact that the micro-organisms of the mouth secluded and incorporated with debris etc., are able to resist the transient presence of antiseptics in such strengths as would not injure the mucus membrane was overlooked to a great extent, and it has been shown that in order to get any appreciable bactericidal action it is necessary to keep the antiseptic mouthwashes—which have so far been devised—in the mouth for a very inconveniently long time. Furthermore, antiseptics do not dissolve the bacteria or viscid food remains which more or less constantly cover the bacteria at those parts of the teeth which are not kept clean by the friction of the food. Even those antiseptics which

give off nascent oxygen and are supposed to penetrate, do not appear to have any appreciable effect. Thus if some of the *materia alba* is observed before such antiseptic wash is used, and then immediately afterwards, no appreciable difference is observable even though much bubbling of nascent oxygen has taken place. Lastly, no antiseptic has yet been brought forward which will help rather than retard the liquefaction and consequent removal of albuminous substances which may have collected in abnormally great and therefore harmful amounts. Nevertheless, antiseptic mouthwashes have their uses, but these are for the sake of surgical cleanliness before a surgical operation or for the treatment of some diseases of the mouth rather than for daily use in the prevention of caries—and their use must be preceded by *thorough and careful cleansing by expert hands* if anything approaching asepsis is to be hoped for. But that such thorough cleansing and sterilizing the mouth is desirable—indeed imperative—before operations on the tonsils, larynx, etc.,²¹ and no doubt more especially operations on the oesophagus and stomach, seems to have been proved beyond the possibility of a doubt. Under such circumstances it is certainly preferable to risk a slight superficial disturbance of the mucus membrane of the mouth than septic infection of a wound.

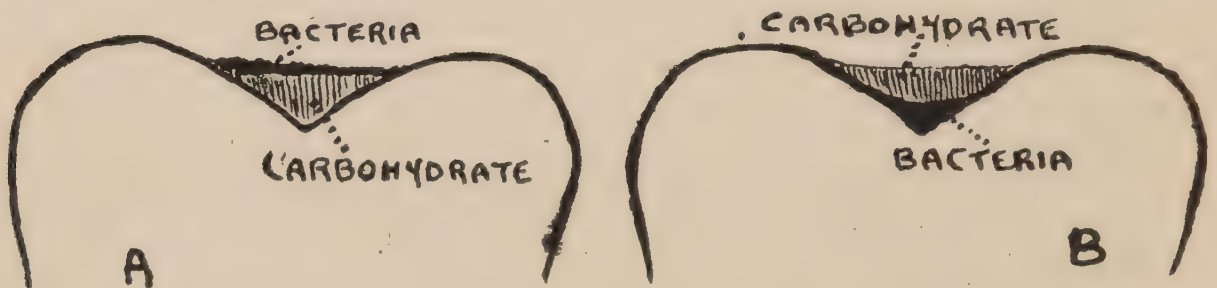
In a general way it may be said that the mucus membrane (or skin) is the first line of defence against pathogenic micro-organisms when this is intact and healthy, and in ordinary daily life it is most essential that the mucus membrane of the mouth should be in a perfectly healthy state, and nothing should be used in a routine way which may injure its vitality. Unless it is known to be unhealthy or not intact, it is doubtful whether the risk of injuring the mucus membrane by the daily use of antiseptics can be advantageously recommended. In this connection the "Lancet," after reviewing some investigations on this subject concluded by saying, "It is obvious that further investigations must be undertaken before the daily use of an antiseptic mouthwash by healthy persons can be recommended."²⁶ And a like conclusion was indicated in the British Medical Journal.²⁷

THE TOOTHBRUSH.

The use of the toothbrush is, or has been, relied upon more generally than any other procedure. Unfortunately it is not so satisfactory as used often to be supposed, for even when carefully and skilfully used it is difficult to get it to brush the teeth on their approximal surfaces. Nor is its use free from the likelihood of abuse. The delicate gingival margins are often injured, more especially over the front teeth, especially those which are prominent and situated on the left side of the mouth, when the brush is frequently too vigorously used by right-handed persons. When but gentle pressure is used so as to avoid injury to the gum margins the bristles of the brush do but little good in removing any adherent matter from the crevices of or between the teeth if it is at all of a sticky nature ; so that after the toothbrush has been used one may

easily scrape away soft adherent matter even from between the front teeth, and if a phantom set of teeth or a stearined model is covered with a somewhat sticky and coloured material and then brushed as well as the intelligent layman may be presumed to do it, it will be seen that the crevices, say, of the molars, are but imperfectly cleaned and the interdental spaces are not cleaned at all. The illustrations on frontispiece of a stearined model treated in this way indicate how ineffectual the toothbrush always is in cleaning away adherent matter except at those parts of the tooth which are not liable to have food adherent to them, and where consequently the teeth are not liable to decay.

Some of the mouth bacteria are very adhesive and require distinctly vigorous brushing to dislodge them from crevices or partly secluded spots and the toothbrush can hardly compare with detergent foods for their removal. When we remember that during mastication the jaws exert a pressure of from 60 to 90 pounds³ on meat and fibrous foods of a detergent kind generally, we realize the certainty with which the crevices of the teeth on the masticating surface will be cleaned of adherent micro-organisms. Especially is this so when we take into consideration the fact that the pressure



and grinding motion is repeated hundreds, perhaps sometimes thousands, of times during the taking of a substantial meal. Of course, if soft foods are eaten the micro-organisms cannot be removed from the crevices, and the carbohydrates which are taken during the meal may, to a certain extent, be gently pressed into the crevices and thus simply stimulate the growth of the bacteria and the acid that they produce. It is when matted masses or plaques of bacteria are thus furnished with carbohydrate food and protected from the beneficent effects of the saliva that caries is certainly produced. Even though at the end of the meal the superficial part of such carbohydrates were brushed away to a considerable extent, sufficient might be left to supply the bacterial plaque with pabulum enough to produce caries more or less rapidly. This is important and may be represented somewhat diagrammatically by the accompanying drawing of a section through a molar tooth.

In the one case (figure A) the crevices are supposed to have been freed from micro-organisms by efficient mastication of detergent food during the meal, but a little carbohydrate is represented as having been left. When this begins to ferment it will begin superficially, as the bacteria of the mouth will necessarily come in contact with the outer part of the carbohydrate first. Further, the number of micro-organisms derived from the saliva after a meal is relatively

small, and as they eat down into the carbohydrate, so at the same time is the carbohydrate washed away more or less by the saliva.

In the other case (figure B) the bacterial plaque not having been brushed away by food requiring efficient mastication, the carbohydrate which remains in the mouth lies as a covering over the plaque and the micro-organisms immediately give rise to acid fermentation and decalcification of the tooth. The micro-organisms are actually present *in situ* in masses and protected from the neutralizing of the acid formed by the overlying carbohydrate.

It is hardly sufficiently realized how difficult it is to clean crevices with a toothbrush except, perhaps, by those who have tried to clean an ordinary hair comb, or to polish crevices in metals with a brush. In this latter case when the crevices are anything like as deep as they usually are in molar teeth it appears to be quite a hopeless procedure. Nevertheless the teeth can be cleaned to a certain extent with a toothbrush—provided that unhygienic meals have left them dirty—and if only it is attempted to clean the masticating surfaces of the molars and premolars, good without harm will assuredly result ; but if any serious attempt is made to clean the interdental spaces with a toothbrush of any kind yet devised, a serious risk is run of injuring the gingival margins with the bristles of the brush.

From the point of view of the dental toilet rather than from that of the prevention of caries the toothbrush has its uses. It should, however, be gently and carefully used, and if such gentle use does not keep the teeth clean to all appearances, then it is imperative to have the teeth cleaned periodically by skilled hands furnished with all the necessary instruments and accessories required.

Before recession of the gums has taken place the crevices between the teeth and the interdental spaces are normally easily kept physiologically clean when appropriate food is masticated, and there should be no real *necessity* for artificial cleaning. Later in life, however, if the gums have receded, and more especially if in addition to this irregularities and abnormal spaces exist, it is necessary to aid the normal self-cleansing processes artificially. For this purpose, in addition to the toothbrush mouthwashes may be freely used and, if necessary, the toothpick also. A quill toothpick is the most satisfactory and care should be exercised so that the gums may not be injured.

TOOTHPOWDERS.

Toothpowders may be used, not for the prevention of caries, but to remove discoloration from the teeth. Unfortunately their use is frequently the cause of erosion more especially over the neck of some of the more prominent teeth. The serious results, more especially of the gritty toothpowders, have been fully exposed by the late Dr. Miller ; and it would seem that great care should be used in the selecting of a toothpowder for daily use. Nothing of a more gritty nature than precipitated chalk should be used. Gene-

rally, however, toothpowder seems to be quite unnecessary even to keep the teeth looking quite white and clean, except among smokers.

In some mouths, too, a dark stain—which can be removed with a steel instrument—is formed either in spite of the use of a toothpowder or possibly sometimes on account of it. If careful observation is made it will be seen that the toothbrush with toothpowder brushes the most prominent part of the tooth so thoroughly that the enamel is kept polished and even worn away; the next part of the tooth not so exposed to the brush and toothpowder appears to have the mucus coating brushed away so that this dark tartar has nothing to prevent its deposition, and being very adherent to the tooth it is not brushed away. The third zone, *i.e.*, between the teeth and close to the gum margin, the mucus is only brushed partly away and the enamel remains clean under this. The dark stain frequently leads to the further use and abuse of toothpowders. However, as has been observed, toothpowders do not prevent caries; and as their use is rather a matter of appearance than for the prevention of caries they need not be referred to further here.

In conclusion, it may be said with reference to the artificial procedures in general that they are not all innocent and innocuous. Rinsing the mouth after meals, however, does good if adherent carbohydrates have been left in the mouth, and this procedure cannot be harmful, although equally satisfactory results may be derived from drinking water or certain other more refreshing fluids (preferably slightly acid and not too sweet) after a meal,³⁹ while brushing the teeth with a medium or even hard brush used gently is generally useful from the point of view of appearance at least. Brushing the teeth after every meal and on going to bed can scarcely be recommended as a routine procedure; it diverts peoples' attention so thoroughly from the knowledge that their teeth ought to be cleaned by the normal physiological processes, and from the fact that when the meals are properly arranged they do actually clear the bacteria out of their mouths and leave no carbohydrates behind which would injure the teeth or give rise to the undue proliferation of micro-organisms. Of course, if or when unhygienic meals are or must be taken, especially at night, then the resulting unhygienic conditions should be mitigated by carefully cleaning the mouth with toothbrush and mouthwash. It is, as a rule, quite inconvenient for most people to brush their teeth regularly except in the morning before breakfast. And to encourage people to bestow a little more care over their teeth when they do brush them once a day is much more useful than a perfunctory, hurried and perhaps too vigorous brush round. It takes at least twenty-four hours for the mucus or what it becomes to accumulate round the teeth—when reasonable habits of mastication are indulged in—to anything approaching the amount which could conceivably be anything but beneficial to the gums and teeth, and though the stomach no doubt can deal with them it is rather desirable that the bacteria should be brushed out of the mouth (to a certain extent at least) *before* the breakfast. If they are not they will be taken into the stomach to a great extent during the meal to be disposed of there.

When not immoderate in number or exceptional in kind the digested bacteria may possibly be turned to use in producing immunity to ubiquitous pathogenic micro-organisms;⁴⁰ but such immunity does not extend to caries, because caries is a fermentative process external to and uninfluenced by any vital reaction of the tissue it invades, at least in the early stage, and because, moreover, there is no such thing as true immunity to the disease. Fortunately there is not now much fear that artificial methods will take precedence over the more natural methods, for it has been pointed out that "there has been a remarkable consensus of opinion as to the superiority of early mastication, the use of hard and resisting food, and the general exercise of the jaw muscles . . . as compared with soft feeding and artificial cleansing."¹¹—and the above statement is more indisputable to-day than it was when written some six years ago. It is most important that no artificial procedure should be advocated which will appear to countenance unphysiological procedures. It is not only dental caries that has to be considered, and even though we could devise a system of artificial cleansing of the teeth which could be relied upon to prevent caries it would do infinite harm should it induce people to continue using the unphysiological diet, which is the cause of so many diseases besides caries at the present day. As things stand, however, fortunately the *only thoroughly reliable method* of preventing dental caries is the natural or physiological one. And on the other hand, what statistics we have seem to show but little reliance can be put on artificial procedures. Thus in the better-class schools where the toothbrush is at least sometimes used, there is no evidence that the teeth are better than in schools where the toothbrush is not used⁸²—indeed, it is noted that "the better the school the worse the teeth."²⁹ Men and boys, who use artificial methods less than women and girls, seem also to have less caries. Indeed, while having no doubt that artificial methods properly practised do *some* good in preventing the disease, we must admit that there is as yet no satisfactory statistical evidence to show that the artificial procedures—as commonly executed—prevent dental caries.

It would appear that we should regard and advocate the brushing of the teeth rather in the light of a cosmetic than as of any particular value in preventing caries. This view has been expressed in a lead-article in the "British Journal of Dental Science," which says:—

"We have all observed mouths free from caries where no efforts at 'oral hygiene' have ever been made, and we are all familiar with mouths requiring constant dental attention, the owners of which are zealous in the use of the toothbrush and dentifrices. In fact, with respect to the toothbrush, we are of opinion that its use is more of a cosmetic than of a prophylactic nature, though we by no means condemn its use as a means to prevent caries."¹⁹

The only artificial procedures which have a marked and undoubtedly beneficial effect are the various dental operations commonly resorted to, which restore the teeth to functional activity, or remove the diseased conditions which prevent functional activity and consequently the normal self-cleansing processes.

On the Means of Disseminating Knowledge necessary for the Prevention of Dental Caries.

From what has already been said it is obvious that the cleansing power of true or effectual mastication is better almost beyond comparison than artificial cleaning. Efficient mastication not only keeps the teeth clean and free from injurious plaques of bacteria, but the gums are kept clean, healthy, firm and so finely applied to the necks of the teeth as almost to defy the lodgment of all appropriate kinds of foods. The peridental membrane and alveolar processes are kept strong and healthy, and no doubt the gingival organ is likewise benefited. The bones of the jaws also are stimulated in their development, and the teeth are more perfectly implanted and regular than when mastication has been insufficient, and artificial cleansing has been solely relied upon for their welfare. Moreover, digestion and the general health are both directly and indirectly benefited. It is, therefore, the obvious duty of every dental practitioner to instil into his patients the value of efficient mastication, and to get them to understand that no amount of artificial cleansing will make up for the continual transgression of the dictates of physiology, and that this is doubly important with regard to growing children whose habits have yet to be formed. It is hardly necessary to say that the attempt to teach the art of vigorous mastication is *perfectly futile* unless the food is of such a consistency as will stimulate or require it. From Dr. Black's Phago-dynamometric records we observe that the vigour of mastication is *and must be* proportional to the consistency of the food consumed, if the food is masticated at all. Here, however, we are met with a difficulty, for if medical practitioners advocate soft food for children, as in actual practice they very generally do, and the dentist advocates its discontinuance, then the diffusion of the required knowledge is greatly impeded. As the general medical practitioner comes in contact with children at a much earlier age than the dentist does, great havoc may be wrought in children's mouths and teeth before the advice of a dentist may even be thought of. It is, therefore, obvious that medical men must learn or be taught how the mouth may be most effectually kept clean. There are few indeed who realize that the mouth is, or at least ought to be, much cleaner after a meal which really requires mastication than at any other time. The detergent effects of the foodstuffs have admittedly been overlooked. It is not so very long since the idea that a meal invariably left the mouth dirty was generally believed even by dentists, so that we can hardly expect the public to be converted at once to the idea that the meals themselves should be cleansing to the mouth and teeth. It is not too much to say that, notwithstanding its immense importance from the point of view of general health, the natural hygiene of the mouth has in the past to all intents and purposes been entirely overlooked. It is true

that artificial cleansing of the mouth has been insisted on, but that some foods leave the mouth physiologically clean, while others leave it dirty, seems never in any text-book of dietetics to have been so much as mentioned. Foods which lodge about the teeth and do not clean the mouth, have been recommended without the slightest concern as to whether they kept the mouth, and indirectly the alimentary canal, free from chronic fermentation, so long as they were known to be easily digestible and to supply the requisite amount of proteid, carbohydrate, etc. In fact, the viewing of food from its nutritional and not its hygienic value is still a matter for serious regret among those who understand the value of oral and indirectly alimentary hygiene. Thus in reviewing an important medical book¹⁸ recently published, the "British Dental Journal" said, "We are at the outset pained to find that wherever a dietary is given in detail in this work, as being specially adapted for school children, no thought apparently has been given to the fact that human teeth are primarily intended for mastication, and that upon the functional activity of the teeth depends the proper development of the jaws; again, we would point out that a diet should be so arranged as to provide a natural toothbrush, and not be composed of those very ingredients which on fermentation lead to the production of lactic acid and consequent decalcification of the dental enamel."¹⁹ It is obvious that the first thing required for the diffusion of the requisite knowledge is to have it clearly taught in text-books for dentists and medical practitioners. We may say that as far as dental text-books are concerned this has just recently been done,⁹ and is further about to be done in a forthcoming text-book,² and from what we can gather, what is being done in England to-day will, in the course of time, be done in other countries. With regard to medical text-books, unfortunately the importance of the subject has not yet been fully realized by all the writers. Some, however, have recognised the more modern teaching of dentists, and further have advocated an abandonment of the current practice of pap feeding for children,⁶ not only on account of the teeth, but because of harmfulness with regard to the alimentary canal³⁶ and body generally.³⁸ Notwithstanding this, however, it would seem desirable that more attention should be paid to the hygiene of the mouth by medical practitioners, and only good would result from requiring from medical students an elementary knowledge of the principles of oral hygiene. Moreover, fuller recognition of dentistry as a branch of medicine at the universities where medical degrees are granted should be demanded. All this is important because the subject of oral hygiene is necessarily associated with questions of dietetics, and consequently in this matter it is to the medical profession that the public look largely for guidance. As regards the dental branch of the profession, it has been and is doing excellent work so far as that is possible under existing circumstances. The British Dental Association and the School Dentists Society, have made statistical investigations which have done much to awaken both the medical profession and the public to the great importance of the subject. Here it is hardly necessary

to say that the treatment of school children's teeth should always be accompanied by instructions as to the prevention of the disease which will be effectual. Otherwise the chronic irritation of increasing rates, and the almost certain recurrence of the disease within a few years will most assuredly give rise to the suggestion that such treatment is not initiated by the highest motives. This would be a great misfortune, because the treatment of school children's teeth is itself of importance in preventing further caries. It makes the children able to eat food suitable for the hygiene of the mouth and alimentary canal, together with all its concomitant and consequent advantages. From what we have just said it may be observed that the best means of educating the public is through what may be called the recognised channels ; that is to say, those with special knowledge must expound the subject in such a way that the leaders of medical thought and writers of text-books shall become acquainted with the truths, and when this is done there is but little fear but that the truths will gradually become generally known. The public have always looked to the medical profession for guidance, and there is no higher authority to whom they are able to appeal, and therefore no efforts should be relaxed, either in regard to perfecting the knowledge of the medical practitioner in this special branch of learning, or in bringing before his notice the reasons for considering the hygiene of the mouth as the most important part of preventive medicine.

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APPENDIX.

Foodstuffs and Dental Caries.

NOT CLEANSING AND LIABLE TO INDUCE DENTAL CARIES.

Farinaceous and sugary food in general without fibrous element.

Examples: Sweet biscuits and cake; bread and marmalade; bread and jam; new bread without crust; bread soaked in milk; milk puddings; porridge and milk; stewed fruit; chocolate and sweets of all kinds; honey.

Liquids: Cocoa and chocolate.

The above foods should not be eaten except when followed by foods of the cleansing kind.

CLEANSING AND PREVENTIVE OF DENTAL CARIES.

Fibrous foods generally.

Examples: Fish, meat, bacon, poultry. Uncooked vegetables, lettuce, cress, radish, celery. Cooked vegetables are as a rule cleansing, but in a less degree than uncooked vegetables.

Stale bread with crust; toasted bread of all kinds; twice baked bread; pulled bread and cheese. Savouries. Fresh fruits, especially those requiring mastication, *e.g.*, apples. Fatty foods, *e.g.*, butter and margarine. Liquids: Tea, coffee, water, also soups and beef tea.

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